Use of Internal Arteriovenous Fistula in Home Haemodialysis

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Summary: Five patients with previous experience of home haemodialysis (lasting one to two years) had internal arteriovenous fistulae created in a previously non-cannulated limb. After training of the spouses or patients to insert the needles, the arteriovenous cannulas were removed and the patients maintained on fistula dialysis in the home, unattended, overnight, for periods of 1 to 11 months (total patient experience of 30 months). All patients expressed a preference for the arteriovenous fistula, and no significant medical complications have been noted to date.

The safe use of a blood pump in the home, overnight, was achieved by the addition of an extra monitor on the outflow (arterial) blood line.

Introduction

Maintenance haemodialysis for chronic renal failure is still considered a difficult and demanding treatment (Drukker *et al.*, 1968). Consequently this therapy is still available to only 5-10% of potential patients in the western world, and a majority of patients with chronic renal failure die prematurely and unnecessarily.

One attempt to widen treatment availability has been the use of the domestic environment for maintenance haemodialysis. Since its introduction four years ago (Shaldon, 1964; Curtis *et al.*, 1965) there has been a progressive growth of this form of treatment and several centres have now reported successful results (Hilton *et al.*, 1968; Rae *et al.*, 1968; Shaldon and Oakley, 1968). However, it has become apparent that the major limiting factors in the widespread use of home haemodialysis are recurrent medical problems associated with the external Silastic-Teflon shunt. Shunt problems have inevitably required specialist aid and have thus hindered the general practitioner in his ability to maintain effective medical supervision of the patient in a domestic environment.

In an attempt to reduce the role of specialist involvement in domestic maintenance haemodialysis a trial of the internal arteriovenous fistula has been undertaken in a domestic environment since October 1967. This communication describes preliminary results achieved in five patients.

Patients

Five patients (four men and one woman) aged 18 to 45 (Table I), all with end-stage renal failure, who had previously been well maintained on maintenance haemodialysis in a domestic environment for periods of between one and two years, had a standard laterolateral internal arteriovenous fistula (anastomotic size 0.3-0.5 mm.) created between the radial artery and a suitable vein (Hanson *et al.*, 1967) in a previously non-cannulated arm. No attempt was made to use the arteriovenous fistula for 4 to 12 weeks after surgery. All patients were dialysed three times a week on a small-volume two-layered Kiil dialyser, using warm single-pass dialysate at 500 ml./min. (Shaldon *et al.*, 1964) and a model A Milton Roy automated monitoring and supply unit incorporating a blood-leak detector (Shaldon *et al.*, 1966). In addition, an extra monitor was placed on the outflow line (arterial) which was capable of

detecting alterations in the pressure within the line by collapse of a thin-walled sac that activated a pressure switch and an alarm system for cutting out the blood pump and rendering an auditory alarm signal if positive pressure changed to vacuum pressure. A Watson Marlow MHRE flow inducer was used as a blood pump, and all dialyses were pumped at a blood flow rate of about 200 ml./min.

TABLE I.—Patient Data

Case No.	Age	Sex	Marital Status	Occupation	Disease	Duration (D.M.H.T.) (months)		
						Shunt	Fistula	Combined
1	45	M	M	Ski instructor	Chr. G.N.	27	11	38
2	35	M	M	Farmer	Chr. G.N.	12	7	19
3	25	F	M	Circus artiste	Chr. P.	12	6	18
4	18	M	S	Student	Chr. G.N.	11	5	16
5	41	M	M	Executive	Chr. G.N.	18	1	19

D.M.H.T. = Domestic maintenance haemodialysis therapy. Chr. G.N. = Chronic glomerulonephritis. Chr. P. = Chronic pyelonephritis.

A modified disposable blood line was used in which a blood pump segment and the collapsible pressure sac were incorporated in the outflow line (arterial).¹ A standard return line (venous) with bubble trap was used and pressure was also monitored in the return line at the bubble trap by a "fail-safe" pressure alarm gauge which cut out the blood pump on a rise or fall of pressure greater than the alarm limits (Bienenstock and Shaldon, 1963). Continuous heparinization was used with each dialysis. Unsiliconized 14 gauge stainless steel thin-walled needles²⁻⁴ were used for venepuncture, after local anaesthetic infiltration of the puncture site with lignocaine hydrochloride (Xylocaine) 2%. Protamine 1-2 ml. of a 5% solution was administered routinely at the end of each dialysis.

Results

All patients were trained while a functioning Silastic-Teflon shunt was still present. Training was supervised by nursing staff who had previously become experienced in fistula venepuncture techniques. In four instances the spouse was trained (Fig. 1), and in one instance the patient himself was trained to insert the needles (Fig. 2). No patient or spouse had any previous medical or paramedical training. The technique of

FIG. 1.—Case 2. Wife inserting needles.

¹ Capon Heaton & Co., Ltd., Hazelwell Mills, Sturichley, Birmingham 30.
² Bard Davol Ltd., Valley Bridge Road, Clacton-on-Sea, Essex.
³ Capon Heaton & Co. Ltd., Hazelwell Mills, Sturichley, Birmingham 30.
⁴ Baxter Laboratories Ltd., Thetford, Norfolk.

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venepuncture of a high-pressure system required careful supervision in its initial stages until confidence was established. The first patient started using the technique in the home after

FIG. 2.—Case 4. Patient inserting needles himself.

two training sessions, but on average 9–10 training sessions were required to obtain confidence (Table II). The Silastic-Teflon shunt was electively removed after a further period of time (average two to three weeks of successful use with the arteriovenous fistula in the home). Total patient experience to date is 30 months (range: 1 to 11 months) and comprises a total experience of 365 dialyses.

TABLE II.—Fistula Experience

Case No.	Venepuncture	Training Time (Dialyses)	Home Dialyses with Fistula	Repuncture or Failed Puncture
1	Spouse (housewife)	2	130	9
2	" (circus artiste)	9	88	4
3	" (circus artiste)	10	75	2
4	Self	10	60	6
5	Spouse (housewife)	9	12	1

General medical health has been well maintained and no major medical problems have been encountered. No patient has received any antibiotic therapy since having the external shunt removed. Biochemical control has shown a 10% improvement in small molecular nitrogen compounds associated with a higher blood flow rate. Haematocrit levels have not significantly altered (mean 31% ; range 16–45%) and no patient has required transfusion (Table III).

TABLE III.—Haematological and Biochemical Data

Case No.		P.C.V. (%)	Transfusions	Pre-dialysis*			
				Blood Urea	Uric Acid (mg./100 ml.)	Creatinine	24-hr. Urine Volume (ml.)
1	S	46	0	160	6.9	10.5	0
	F	45	0	140	6.3	9.5	
2	S	29	0	150	7.2	11.5	50
	F	30	0	130	6.5	10.4	50
3	S	16	0	130	7.8	10.6	300
	F	16	0	125	7.0	10.2	300
4	S	22	0	105	6.9	9.7	0
	F	24	0	100	6.5	9.5	0
5	S	37	0	160	7.5	12.5	100
	F	38	0	140	7.0	11.4	100

*All patients eating a 70–80 g. protein diet and dialysed for 10 hours three times weekly.
S = Silastic-Teflon shunt. F = Arteriovenous fistula.

Complications.—There has been no major medical or technical complication associated with the use of the fistula in the home. (1) Minor complications, initially associated with inexperience and premature use of the fistula, resulted in bruising of the fistula puncture sites. (2) Failure to puncture a vein adequately occurred in an average of 3% of dialyses. However, there was a reduction in puncture failures as experience increased and as the veins enlarged. (3) Complications during dialysis

have consisted of obstruction of the return needle associated with fibrin formation in the needle in 3% of dialyses. This complication occurred predominantly in two patients with high haematocrits (38% and 45%) but was reduced in incidence by increasing the systemic heparinization rate during dialysis and may be further reduced by the use of siliconized needles (Cohen *et al.*, 1968). The problem was resolved during dialysis by removal of the needle and repuncture. (4) False alarms due to alteration in the outflow or return pressures have not been excessive, and all patients report that they sleep as well, with no greater frequency of pressure alarms compared with their previous experience on Silastic-Teflon shunts.

Patient Opinion.—All patients expressed a preference for the internal arteriovenous fistula and were determined to avoid having further external shunts. They rated the venepuncture technique as a minor inconvenience which was more than compensated for by its numerous advantages. All have noted a freedom psychologically from anxiety previously associated with the function of their shunt and enjoy physical activities previously impossible, such as golf, swimming, acrobatics, mountain climbing, and hard manual labour. Their acceptance by friends has been more normal and there has been better general health associated with a complete absence of infection.

Discussion

The use of the internal arteriovenous fistula in hospital dialysis has been reported with increasing enthusiasm since its introduction by Cimino and his colleagues in 1965 (Brescia *et al.*, 1966). The majority of reports have emanated from centres using coil dialysers with poor external cannula results (Hanson *et al.*, 1967 ; Ackman *et al.*, 1968 ; Patel *et al.*, 1968 ; Verberckmoes *et al.*, 1968). The advantages stressed related to patient welfare, and patient preference for this technique has been adequately confirmed in our experience to date. However, it is salutary to note that our cannula experience has not been poor. In fact, cannula survivals at the National Kidney Centre are well above world average, and only one out of the five patients was experiencing any major cannula problems. In the other four patients cannula survival had averaged over 12 months for both arterial and venous cannulas and the arteriovenous cannulas were removed electively. In spite of this all patients agreed that the fistula technique was infinitely superior.

From the medical management point of view, once the technique had been mastered no medical problems have occurred to date in 30 months of patient experience. Limiting factors in the technique at the moment are associated with a variable quality of the internal smoothness of the stainless steel needles and the period of time after creation of the fistula before it can be easily used by the lay person. The former problem appears soluble by siliconization of the needles. Experience with Teflon catheters in place of stainless steel needles has proved less satisfactory, as lay persons found them more difficult to introduce, and it is our impression that there is more trauma associated with their use. Repeated trauma may well be the limiting factor to long-term use of fistula sites as in our experience in 1961–3 ; with repeated femoral vessel puncture technique (Shaldon *et al.*, 1961) in long-term dialysis, the development of scar tissue over the femoral vessels became the limiting factor in accessibility to these vessels. To date, however, examination of the puncture sites shows adequate healing, with no evidence of scar formation and no difficulty in repuncturing previously punctured sites, for periods of up to 11 months, involving over 130 dialyses in the patient longest on treatment with this technique.

The adaptation of this technique to use in a domestic environment has involved the initial training of nursing staff and then of a patient or spouse to master the technique of venepuncture and extra monitoring of the blood circulation, as a blood pump has been used unattended overnight. The former problem has been tackled in two new patients by insertion of Silastic-Teflon cannulas at the beginning of training and

the creation of the arteriovenous fistulas in the opposite limb when the patient was no longer in congestive heart failure or significantly hypertensive. This precaution has been taken to avoid significant haemodynamic effects with the arteriovenous fistula, though in clinical and radiological observation to date none of our patients has shown any evidence of cardiac decompensation.

Training for home dialysis has proceeded by using the standard Silastic-Teflon shunt for periods of up to two months and then establishing the patient in his home. After a period of one month in the home these new patients have returned to the centre to begin training for the use of their arteriovenous fistulas. It is important to stress that the mastering of the arteriovenous fistula technique for home dialysis should be delayed until the patient and family are competent at conventional home haemodialysis. After the period of training with the fistula has been completed the patient has returned home for a further month, and finally the Silastic-Teflon cannula has been electively removed.

The major danger of pumped haemodialysis is the risk of air embolus from the creation of a vacuum in the outflow line between the blood source and the blood pump. The use of a collapsible pressure monitor proximal to the blood pump has proved satisfactory in preventing the development of a vacuum in the outflow line, but in addition a monitor for detecting the blood level in the return bubble trap is being evaluated to further minimize the risk of air embolus. Additional alarms due to the extra monitors have not been troublesome, and patients have learnt to accept the occasional extra alarm as part of the inconvenience of the use of the fistula. There has been no evidence of increased red cell destruction by the continued use of a blood pump, as indicated by an absence of a rise in free plasma haemoglobin levels after dialysis. In addition there has been a steady or rising haematocrit in all patients and zero transfusion requirements.

The most significant medical fact has been that no patient has required antibiotics since using the fistula in the home. The implication of this on the general health of the patient and the absence of recurrent infection problems remains to be more fully evaluated.

The economic impact of fistula dialysis in the home shows a slight increase in running costs due to the needles, which is more than offset by savings in the dressings required, antibiotics not used, and the cost of recurrent cannulation and declothing procedures.

Conclusions

The internal arteriovenous fistula would appear to be superior to the use of the arteriovenous shunt in home haemodialysis, eliminating many of the medical problems associated with home haemodialysis and offering patients a freer and more normal prospect of life.

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REFERENCES

- Ackman, C. F. D., Khonsari, H., Mount, B., Rege, P., and Dossetor, J. B. (1968). *Proc. Europ. Dial. Transpl. Ass.*, 4, 86.
 Bienenstock, J., and Shaldon, S. (1963). *Lancet*, 2, 815.
 Brescia, M. J., Cimino, J. E., Appel, K., and Hurwich, B. J. (1966). *New Engl. J. Med.*, 275, 1089.
 Cohen, S., Lidsky, I., Kest, L., Kastagir, B., and Vertes, V. (1968). *Trans. Amer. Soc. artif. intern. Organs*, 14, 421.
 Curtis, F. K., Cole, J. J., Fellows, B. J., Tyler, L. L., and Scribner, B. H. (1965). *Trans. Amer. Soc. artif. intern. Organs*, 11, 7.
 Drukker, W., Jungerius, N. A., and Alberts, C. (1968). *Proc. Europ. Dial. Transpl. Ass.*, 4, 3.
 Hanson, J. S., Carmody, M., Keogh, B., and O'Dwyer, W. F. (1967). *Brit. med. J.*, 4, 586.
 Hilton, D. D., Blainey, J. D., Dawson-Edwards, P., Dorricott, N. J., and Simpson, K. M. (1968). *Proc. Europ. Dial. Transpl. Ass.*, 4, 35.
 Patel, R., Lidsky, I., Vertes, V., Kest, L., and Cohen, S. (1968). *Brit. med. J.*, 1, 414.
 Rae, A. I., Barnett, B. M. S., Davidson, R. C., and Blagg, C. R. (1968). *Proc. Europ. Dial. Transpl. Ass.*, 4, 28.
 Shaldon, S., Baillo, R., Comty, C., Oakley, J., and Sevit, L. (1964). *Dialysis*, p. 66. Seattle.
 Shaldon, S., Chiandussi, L., and Higgs, B. (1961). *Lancet*, 2, 857.
 Shaldon, S., Baillo, R., Comty, C., Oakley, J., and Sevit, L. (1964). *Proc. Europ. Dial. Transpl. Ass.*, 1, 233.
 Shaldon, S., and Oakley, J. J. (1968). *Proc. Europ. Dial. Transpl. Ass.*, 4, 24.
 Shaldon, S., Ramalingum, C., and Baillo, R. A. (1966). *Proc. Europ. Dial. Transpl. Ass.*, 2, 280.
 Verberckmoes, R., et al. (1968). *Proc. Europ. Dial. Transpl. Ass.*, 4, 73.

Value and Limitations of Electrocardiogram in Diagnosis of Slight and Subacute Coronary Attacks

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Summary: The electrocardiogram recorded at the initial consultation was compared with the final diagnosis in 211 consecutive suspected slight or sub-acute coronary attacks in 206 patients.

In 77 (36%) of the 211 episodes, acute (or subacute) myocardial infarction was finally diagnosed. The initial E.C.G. showed a diagnostic pattern in only 19 (25%) of these 77 episodes; in 39 (50%) it was abnormal but not diagnostic of recent infarction; while in 19 (25%) the E.C.G. showed no abnormality classified under the Minnesota Code, though in 16 of these there were definite minor changes.

In 61 (29%) of the 211 episodes acute myocardial infarction was excluded and an alternative diagnosis was made. The E.C.G. was strictly normal in only 23 (38%) of these 61 episodes; in 15 (25%) it showed minor abnormalities, and in 23 (38%) it was grossly abnormal.

Introduction

The value of the electrocardiogram (E.C.G.) in the diagnosis of major attacks of myocardial infarction is well established, but it is too readily assumed that the E.C.G. affords a simple and decisive means of diagnosis in the case of slight and subacute attacks. Because of this there is a growing demand that hospitals should make arrangements for carrying out E.C.G. examinations of patients at the request of their family doctors, and report on the tracings without the cardiologist seeing the patient. It is clearly desirable that the family physician should be furnished with every means for increasing his diagnostic accuracy, but it seems to me that the value and limitations of the E.C.G. in the diagnosis of suspected coronary attacks need to be clearly defined. The following study was undertaken with this object. In essence it is a correlation between the E.C.G. pattern recorded

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